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**General Technical
Report RM-242**

Recycling and Long-Range Timber Outlook

Peter J. Ince

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Summary

This report updates the Forest Service analysis of long-range trends in paper recycling and impacts on the timber outlook in the United States. Two updated scenarios are presented, a "base" scenario and a "high recycling/waste reduction" scenario. Projections extend five decades into the future.[2] In the base scenario, rapid increases are projected in U.S. paper recycling rates in the 1990s, followed by more gradual increases in subsequent decades. Results are compared to the earlier 1989 RPA Assessment, which assumed much slower growth in recycling rates. Increased paper recycling affects timber markets by extending timber resources and expanding fiber supply. Roundwood pulpwood demand is projected to increase at a more modest rate than projected in the 1989 Assessment, while pulpwood supplies increase (particularly for softwoods). Consequently, real prices for delivered Southern pulpwood are projected to remain relatively stable for softwoods, and to increase gradually for hardwoods. The balance of trade is projected to swing strongly in favor of U.S. exports for pulp, paper and paperboard. In general, projections indicate that U.S. production of pulp, paper, and paperboard will continue to increase, with growth in fiber demands matched by growth in domestic fiber supplies.

Although increased recycling will extend fiber supply, results indicate that the United States still faces serious future supply problems for sawtimber. In this updated analysis, future National Forest timber harvest levels are assumed to decline (to levels much lower than assumed in the 1989 Assessment). Other assumptions updated since the 1989 Assessment include higher projected demand for softwood lumber and plywood in the United States, lower Canadian lumber production, lower private industrial sawtimber harvests in the U.S. West, and various revisions to timber growth assumptions, particularly in the U.S. South. Consequently, growth in domestic sawtimber supply is not expected to match growth in sawtimber demand. Softwood sawtimber prices in the United States are projected to increase substantially in the decades ahead, despite increased paper recycling. Real stumpage prices for softwood sawtimber in the South for example are projected to nearly double between 1990 and 2020; and southern sawtimber prices are projected to be higher by the year 2000 than projected in the 1989 Assessment. However, increased recycling will help ameliorate timber price increases somewhat. In the longer term (2010 and beyond), sawtimber prices are projected to be lower than projected in the 1989 Assessment, partly because of increased recycling.

In the alternative "high recycling/waste reduction" scenario, much more rapid increases in recycling and lower future per capita paper and paperboard consumption levels are projected. Roundwood pulpwood consumption and pulpwood prices are projected to be substantially lower than in the base case. However, softwood sawtimber prices still are projected to increase in the decades ahead, at a somewhat slower rate of increase than in the base scenario.

[2]Projections shown in this report are the result of long-range economic modeling based on economic supply and demand theory. The projections are intended only to provide professional opinion about directional trends of the future. The projections should not be viewed as official or scientific endorsement of specific outcomes or events. They do not represent outcomes which are certain to occur in the future. Ongoing changes in markets and technology will certainly render these projections obsolete, and reasonable variation in data and assumptions can lead to a wide range of projected future outcomes apart from projections shown in this report. Projections shown in this report were derived from the draft NAPAP Model Base scenario results developed in March, 1993 (including TAMM run LR 126), and the draft NAPAP Model results for "high recycling/waste reduction," which were developed in June, 1993 (including TAMM run LR 130). Draft projections shown in this report will vary slightly from final results, which will be published in the 1993 RPA Timber Assessment Update report.

Emergence of the Issue

People understand that paper recycling can "save trees;" but, the precise impact on timber supply and demand is complicated by economic behavior and by other ongoing adjustments to timber supply and demand. In a simplistic sense, use of recycled fiber in papermaking directly avoids harvesting of trees for pulpwood, to some extent. However, other economic and behavioral adjustments complicate the issue. Reduced pulpwood demand will extend timber supplies, making timber harvesting more economically attractive than it would be otherwise. Trees which are "saved" by recycling are likely to be harvested for end uses other than papermaking. Therefore, increased recycling will tend to favor greater overall consumption of forest products in domestic and overseas markets. Other adjustments to timber supply and demand, such as increased forest preservation, also will affect the long-range timber outlook. Fundamentally, the issue concerns the short-run market allocation of wood and fiber resources and the long-run allocation of land, technology, and capital resources to the forest products sector. The issue has emerged because of a landfill crisis and waste management dilemma in the United States, which has precipitated a substantial increase in paper recycling.

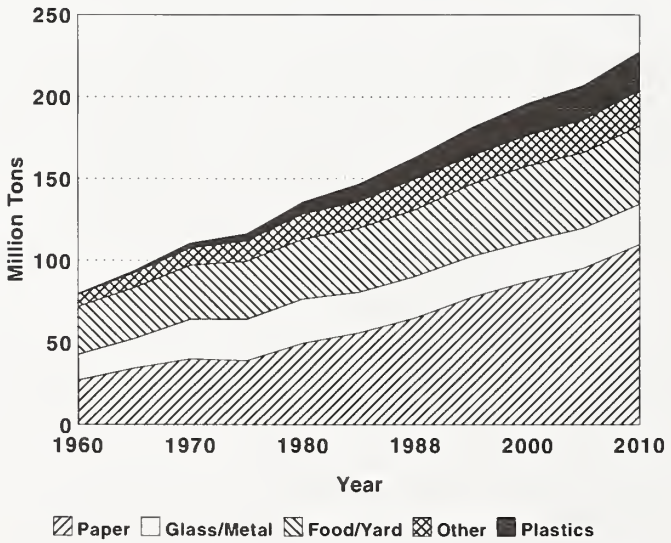
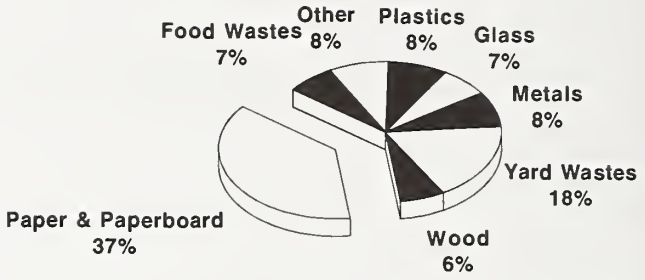


Figure 1.—Historical and projected trends in waste maerials generated annually in MSW, 1960-2010 (U.S. EPA).



Total Weight = 195.7 Million Tons

Figure 2.—Estimates proportions of materials generated in MSW, 1990 (U.S. EPA).

Landfill Crisis and Waste Management Dilemma

In industrialized countries of North America, Europe, and East Asia, the latter half of the 20th century has been characterized by sustained economic growth, rapid expansion of consumer goods markets, and increased urbanization. In the United States, for example, a growing and more urbanized economy consumed paper and paperboard products in steadily increasing volumes, rising from 24 million short tons annually in 1949, to nearly 87 million tons in 1990 (API 1992). Although organized means of trash collection and disposal were provided in industrialized countries throughout this period, the approach to waste management evolved. In some instances, waste disposal created environmental and economic problems. Groundwater contamination and air quality are among the more significant environmental and human health concerns associated with landfills and waste incineration in the United States (EPA 1989, 1988; OTA 1989). Increasing regulation, negative impacts on property values, and declining availability of waste disposal sites have contributed to increasing costs for waste disposal.

The volumes of municipal solid waste (MSW) generated in the United States have increased and are projected to increase substantially in the years ahead. Figure 1 shows historical and projected trends in waste materials generated annually in MSW (EPA 1990). It was estimated that in 1990, 37.5% (by weight) of all MSW generated in the United States was paper and paperboard. Figure 2 shows estimated proportions of materials generated in MSW (EPA 1992). EPA has projected that the amount of MSW gener-

ated in the United States will exceed 220 million tons by the year 2010, without additional source reduction (EPA 1992). Without significant changes in recycling or consumption patterns, paper and paperboard would remain the largest single component of MSW in the United States.

Since the mid-1980s, there has been a significant and continuous growth in paper recycling rates in the United States. In economic terms, the increase in paper recycling rates since the mid-1980s was primarily an economic response by the paper industry to increased supplies of paper collected and recovered for recycling. Recovery of paper for recycling increased in recent years because of widespread expansion of paper collection and sorting programs (e.g. community-based curbside collection, sorting, and office wastepaper collection). Such programs were directly or indirectly a response to long-term environmental, economic, and human health problems associated with landfills and waste incineration, and increasing waste disposal costs. Increasing disposal costs have led to expansion of collection and sorting programs, which, in turn, have led to cheaper and more abundant supplies of recovered paper, providing the economic incentive for industrial expansion of paper recycling. Thus, the landfill crisis and solid waste management dilemma have precipitated the recent departure from historical trends in paper recycling.

Relevance to RPA Assessment

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), the National Forest Management Act of 1976 (NFMA), and the Forest and Rangeland Renewable Resources Research Act of 1978 require the USDA Forest Service to develop comprehensive long-range assessments of supply and demand for timber and other forest resources in the United States. The decennial Assessment reports and their interim updates include detailed analyses of the prospective timber supply and demand situation in the United States. The reports include long-range projections of timber market trends (regional supply, demand and prices), forest product demand, domestic production, and technological changes in major forest product sectors of the U.S. economy (including the pulp and paper sector). RPA Assessment reports have been prepared since the 1970s. The timber analysis component of the RPA Assessment

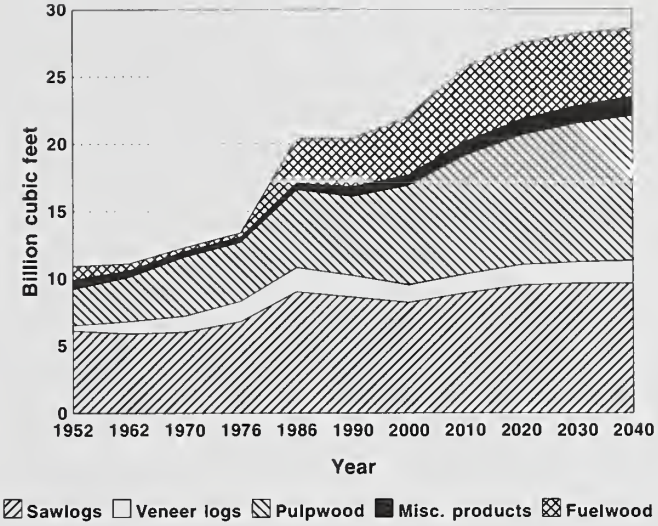


Figure 3.—Roundwood consumption in the United States, specified years 1952-1986, with 1989 RPA base projections of demand to 2040.

follows a much longer tradition of federal timber outlook studies, dating back to the late 19th century (for bibliography of such studies, see Preface to USDA Forest Service 1982). The most recent RPA Assessment report was completed in 1989 (USDA Forest Service 1989a), accompanied by publication of a more detailed long-range analysis of the timber situation in the United States (Haynes 1990). This report was developed in support of the 1993 RPA Assessment Update (1993 Update). The RPA Assessment and interim updates provide a factual and analytical basis for the RPA Program of the USDA Forest Service, a program of recommended agency activities which is revised and submitted to Congress every 5 years under the provisions of RPA.

Looking at data and projections from the 1989 RPA Assessment (Haynes 1990), it was apparent that demand for timber had grown substantially in recent decades, and was expected to grow substantially in the future. Figure 3 shows historical data on timber consumption in the United States, by timber product category, since 1952, along with 1989 RPA Base projections to the year 2040. It could be noted, however, that the 1989 RPA Base projections assumed a very conservative trend in paper recycling rates. Figure 4 shows historical data on timber demand from U.S. forest lands, with imports and exports, along with 1989 RPA Base projections to the year 2040. Of approximately 500 million cubic meters of annual timber harvest from timberland in the United States, in the late 1980s, approximately one-fourth was pulp-

wood supplied directly to pulp mills. In addition, by the late 1980s, timber harvest represented only about 60% of total pulpwood input to pulp mills in the United States; about 40% of pulpwood was obtained indirectly as wood residues (wood chips) from sawmills and veneer mills. Therefore, total pulpwood consumption in the United States, including timber harvest and mill residues, amounted to more than 200 million cubic meters annually, by the late 1980s, or more than 40% of the timber supplied from U.S. timberlands. In the 1989 RPA Base case, this percentage was projected to grow to more than 50% in the decades ahead. Thus, in the 1989 RPA Assessment report, projected growth in pulpwood consumption was a major element in projections of substantially increased timber consumption in the United States.

Although net annual growth and inventory of timber growing stock have been increasing steadily in recent decades, and although timber supply is expected to increase in the future, the 1989 RPA Assessment Base projections showed that overall growth in timber demand would generally exceed growth in timber supply. This resulted in projected increases in timber prices, particularly increases in softwood timber stumpage prices in the U.S. West and U.S. South (Haynes 1990). This general assessment of the future, that timber prices would increase substantially over the long term, was not dissimilar to conclusions of other recent timber analysis studies (USDA Forest Service 1988, USDA Forest Service 1982).

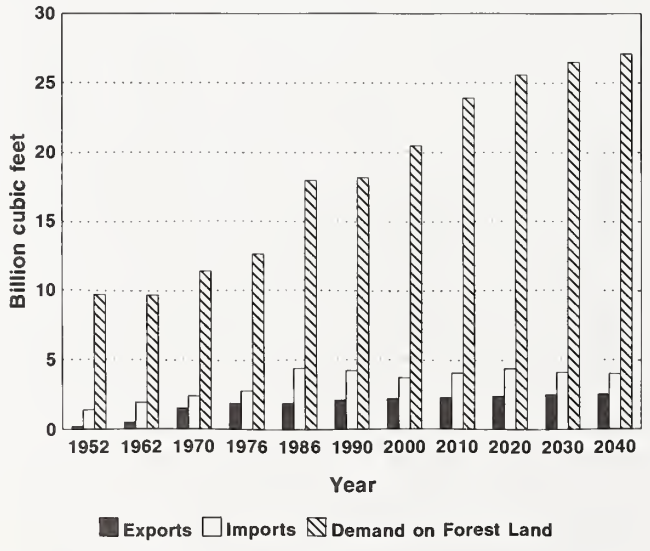


Figure 4.—Timber demand showing exports, imports, and demand on forest land in the United States, specified years 1952-1986, with 1989 RPA base projections of demand to 2040.

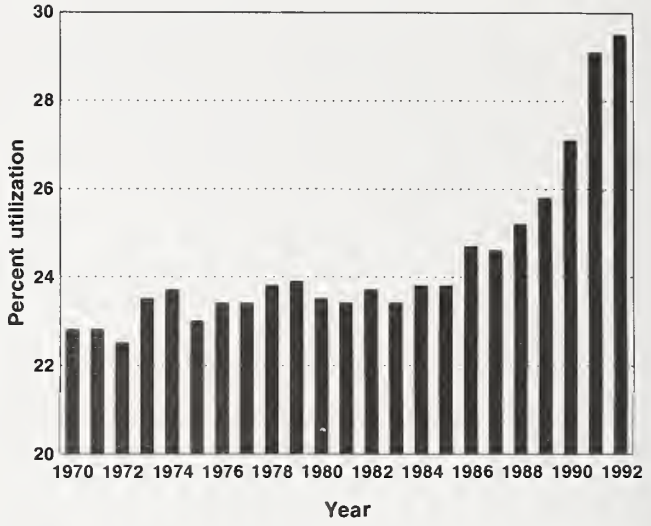


Figure 5.—U.S. recyclable paper utilization rate historical trend (API).

Selection and Definition of the Issue

The 1993 Update was intended to reflect analysis of important issues currently related to long-range forest resource trends, and particularly issues which have remained important since the 1989 Assessment. Certainly, trends in paper recycling have remained an important issue, given the significant upward trend in paper recycling that is now apparent. Figure 5 shows the historical trend in the U.S. recyclable paper utilization rate since 1970 (API 1992). The recyclable paper utilization rate is the ratio of the tonnage of recyclable paper used as fiber input in domestic paper and paperboard mills to total tonnage of paper and paperboard produced. Figure 6 shows the historical trend in U.S. recyclable paper recovery rate for the same period (API 1992). The recyclable paper recovery rate is the ratio of the tonnage of recyclable paper recovered for both domestic use and for export to the total tonnage of paper and paperboard consumed in the U.S. economy. A substantial historical increase in recycling rates began in the mid-1980s (figs. 5 and 6). Also, by 1992, U.S. paper recycling rates actually reached levels which were not forecast to occur in the 1989 RPA Base projections until the next century. Thus, the Forest Service recognized that scenarios such as the 1989 RPA Base should not be viewed in isolation from alternative scenarios which show more realistic trends in paper recycling.

Consequently, in the 1989 RPA Assessment report (USDA Forest Service 1989a), in the supporting timber analysis report (Haynes 1990), and in subsequent reports (Ince 1990; Adams and Haynes 1991), alternative scenarios were published which examined projected impacts of increased paper recycling on timber markets. Generally, such scenarios showed that increased recycling would extend timber supplies and would tend to mitigate projected timber supply shortages and timber price increases to some extent. Thus, one of the more significant conclusions of the 1989 RPA Assessment and subsequent studies was that likely increases in paper recycling could have significant impacts on U.S. timber supply and demand in the decades ahead. For that reason, the issue of recycling and its impact on the long-range timber market outlook was identified by the Forest Service, in 1990, as a key issue requiring further in-depth analysis for the 1993 Update. A summary of results from that issue analysis is described in this report.

Approach and Methods

As in past RPA Assessment studies, the approach of this study was to start with basic assumptions about future economic growth and future population growth in the United States, and develop a partial equilibrium forest product sector model to provide market projections based on those assumptions. In this case, an economic model of the entire North American pulp and paper sector was developed. Modeling methods were based on established principles of economic theory, with application of econometrics, regional market modeling techniques, and capital investment theory applied to technology forecasting. The pulp and paper sector model was linked by iterative solution to other Forest Service models, which encompass solid-wood products (lumber and plywood, etc.), fuelwood, stumpage markets, and timber growth and inventory. Intrinsic assumptions included the assumption that competitive free markets will prevail as the primary mechanism by which wood and fiber resources will be allocated in the North American forest product sector, and that competitive economics will determine the allocation of capital and technological resources over time within that sector. Model constraints and shifts in fiber supply and demand are introduced to simulate potential government policies related to recycling.

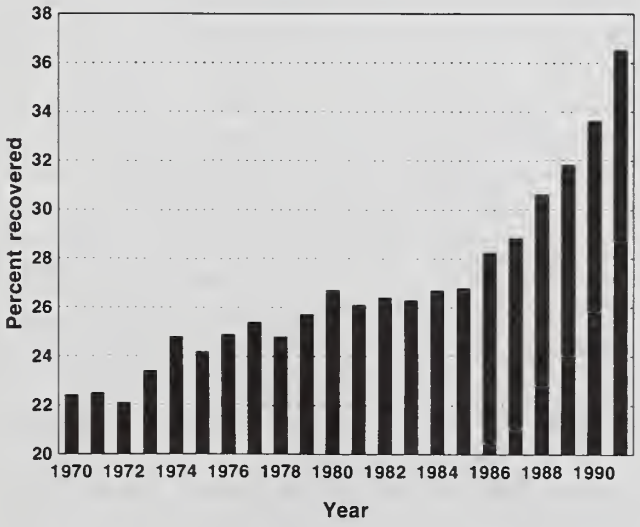


Figure 6.—U.S. recyclable paper recovery rate historical trend (API).

Basic Assumptions

The basic assumptions include assumptions about future population growth and economic growth in the United States. The same basic growth assumptions were applied in all economic models and supporting studies of the 1993 RPA Assessment Update. Growth assumptions are nearly identical to those which were used in the 1989 RPA Assessment and related studies (USDA Forest Service 1989b). RPA growth assumptions were used in this study for years after 1993; actual data and near-term projections were used through 1993.

Only one set of basic population growth assumptions was used for the 1993 Update. Growth in population and the economy has stimulated domestic demand for paper and paperboard products. In the past 50 years, the U.S. population increased by more than 100 million. Projections of the Bureau of Census indicate that U.S. population is likely to continue to grow during the next 50 years, but at a gradually declining rate. Basic population growth assumptions were based on Bureau of Census "middle series" projections with a high immigration assumption. The overall net annual growth rate for U.S. population is projected to gradually decline from about 1% in the late 1980s to 0.3% by the year 2040.

Similarly, only one set of basic economic growth assumptions was used for the 1993 Update. U.S. demand for paper and paperboard products has been closely associated with historical changes in real gross national product (GNP; expressed in constant dollars), as well as increases in population. Projections of GNP growth were obtained from Wharton Econometric Forecasting Associates (WEFA; see USDA Forest Service 1989b). The economic growth assumptions indicate rising affluence of the U.S. population, with a roughly three-fold increase in per-capita real GNP assumed between the year 1986 and 2040. Projections assume that services will account for an increasing share of GNP, although manufacturing and construction activities are expected to increase in absolute terms also, with large increases in the quantities of physical goods produced in the U.S. economy.

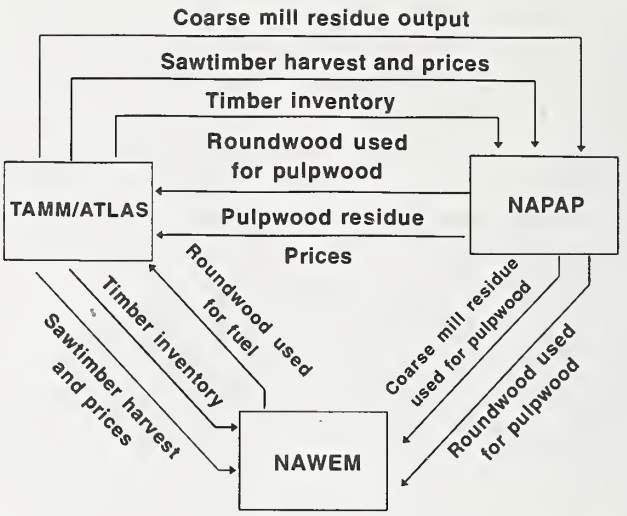


Figure 7.—Iterative data exchange among NAPAP, TAMM/ATLAS, and NAWEM models.

Methods

Various modeling techniques lend themselves to analysis of long-range issues in resource economics and agricultural economics. In recent decades, techniques have evolved from investigation of temporal resource conditions and simple trend extrapolation toward development of more sophisticated mathematical or computer models which simulate dynamic responses or behavioral adjustments over time. Recent experiences in resource economics have provided important lessons on application of modeling techniques. For example, gloomy forecasts of energy shortages made in the early 1970s and optimistic forecasts of agricultural commodity export demands in the late 1970s both proved to be incorrect by the 1980s, for similar reasons. In both cases, analyses depended primarily on trend extrapolation, and failed to account for significant behavioral adjustments which tended to offset earlier trends. Projections of energy shortages based on supply constraints in the early 1970s failed to consider the rapid evolution of more energy-efficient technology and development of new energy sources. Projections of booming U.S. agricultural exports in the late 1970s, based on the historical position of the United States in satisfying growing world food needs, failed to anticipate the widespread adoption of improved agricultural technology worldwide, particularly in developing countries. The behavioral adaptability which is displayed in competitive free markets, coupled with capabilities for technological change often have resulted in an ability to adjust and capitalize on changing resource conditions. One important conclusion is warranted. Assuming that competitive free markets will prevail in North America and that opportunities exist for technological change, analysis of future resource conditions must take into account mechanisms by which markets and technology will adjust to resource conditions and, in turn, how resource markets will be affected by those adjustments.

An economic model was needed in this study to simulate the competitive market allocation of resources throughout the pulp and paper sector, to determine simultaneously the evolution of production technology, regional market equilibria, and trade flows, and to determine the impacts on timber supply and demand, growth, inventory, and prices. The North American Pulp and Paper Model (NAPAP Model) was developed, therefore, to project the competitive evolution of production technology, markets, and trade in the pulp and paper sector. The model simulates evolution of process technology (for using recycled fiber and virgin wood fiber) in all primary paper and paperboard products (e.g. newsprint, printing and writing paper, linerboard, etc.). The NAPAP Model was linked to other Forest Service RPA Assessment models, to project overall timber growth and timber market trends. Figure 7 illustrates how the NAPAP Model is linked by iterative solution with the Forest Service TAMM/ATLAS model (which encompasses timber growth and in-

ventory, timber stumpage markets, lumber, plywood, and other forest products) and the National Wood Energy Model, NAWEM (which encompasses fuelwood markets). Thus, a comprehensive economic assessment of the entire forest and forest product sector is provided in this study. Figure 8 illustrates NAPAP Model production regions in North America (the model encompasses the United States, Canada, and overseas markets).

Other Studies

Much attention has been given, in recent years, to the separate national issues of waste management and the long-range timber market outlook; but, most published studies have not focused on their relationship as a single issue. Studies focused primarily on solid waste management have been sponsored by state and local governments, federal agencies, and environmental public interest groups. Studies focused more narrowly on paper recycling have been sponsored by the pulp and paper industry, states, and consultants or advisors to policy makers at the federal level. Studies focused on timber issues have been sponsored more commonly by the forest products industry, USDA Forest Service, and various public interest groups.

Recycling has become a top issue on state legislative agendas, because of public concern over problems such as solid waste management and environmental pollution, and, to a lesser extent, energy conservation and resource management. The National Conference of State Legislatures, for example, sponsored a report which examined different approaches to developing recycling markets and industries (Thurner and Ashley 1990). In recent years, state recycling efforts have encouraged the collection of recyclable materials but largely ignored the market demand for such materials. Consequently, "state efforts were not always successful and sometimes produced gluts of recyclable materials" (ibid.). Similarly, the United States Conference of Mayors has focused primarily on resource recovery and options to landfilling, sponsoring reports such as an annual report on the status of energy and materials recovery facilities in the United States (see e.g. *City Currents*, Vol. 8, No. 3; The United States Conference of Mayors, National Resource Recovery Association: Washington DC). Similar data on waste combustion facilities are also compiled (but not published) by the U.S. Department of Energy. Public interest groups, such as the Environmental Defense Fund, have sponsored in-depth studies that evaluate economic and environmental aspects of choices which must be made by state and local governments in developing recycling programs and waste incineration facilities (Denison and Ruston 1990). In addition, federal agencies, such as EPA and the Office of Technology Assessment, have sponsored major studies that have provided information on the status of waste management and waste materials generated in the United States (EPA 1988, 1989, 1990; OTA 1989). In general, such studies have provided important and useful information about the current landfill crisis and solid waste management dilemma. However, such studies generally have not examined future consequences or expected outcomes of the dilemma from a national perspective. Thus, the focus of most broad studies has been on the dimension and character of waste management problems from a static perspective, rather than focusing on dynamic factors, such as the likely future evolution of competitive markets or technology in response to the current solid waste management dilemma.

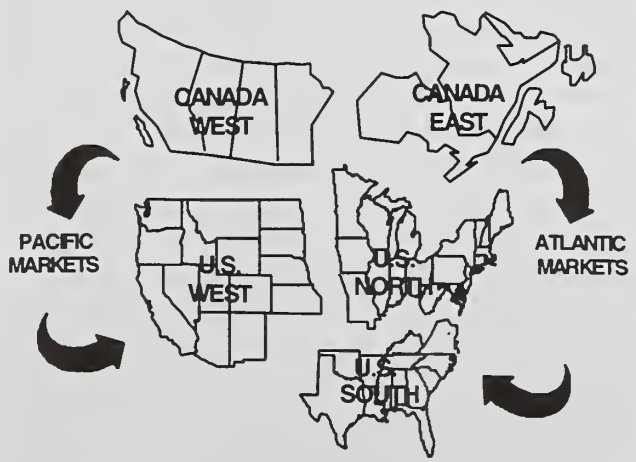


Figure 8.—NAPAP model regions in North America.

In contrast, studies focused more narrowly on paper recycling generally have emphasized the dynamic character of markets or how recycling is developing as a market response to the solid waste management situation. A classic example of such a report was prepared in 1982, for the Solid Waste Council of the Paper Industry (Franklin et al. 1982). The 1982 Franklin Associates study relied heavily on histori-

cal industry data from the American Paper Institute. It discussed, in great detail, the historical evolution of paper recycling, recovered paper exports, and other uses of wastepaper, such as energy recovery. Among the findings were conclusions that recovery and utilization rates would likely increase faster in the 1980s and 1990s than they did in the 1970s, that waste-to-energy facilities would expand with increased collection programs in response to emerging solid waste problems, and that increased utilization eventually could significantly impact prices for recovered paper, if supply limits were reached. A similarly detailed study, describing current trends and the outlook for newspaper recycling, was prepared for the Canadian Government (Hatch Associates 1989). In 1990, a study by Franklin Associates was sponsored by the American Paper Institute, to develop projections of paper recycling levels to the year 1995 (Franklin Associates 1990). The 1990 Franklin report provided the basis for a view that recyclable paper recovery rates would reach 40% by 1995. Subsequently, the American Paper Institute announced their national goal of 40% paper recovery for recycling by 1995. Another study by Franklin Associates examined supply and demand for office wastepaper, with projections to 1995 (Franklin Associates 1991). The report was sponsored by the National Office Paper Recycling Project, managed by the United States Conference of Mayors, with principal support from leading paper companies. The report concluded that both recovery and demand for office wastepaper were likely to more than double between 1990 and 1995. Among various multi-client studies of recycling trends are those of Resource Information Systems, Inc., which , projected that paper recycling will continue to expand in the 1990s, and that paper recovery rates in the United States are likely to exceed the 1995 industry goal of 40% and perhaps reach a level of 55% by the year 2005 (Young 1991).

Despite rapid acceleration in paper recycling rates and growing concerns about timber resource adequacy because of forest preservation, few studies have sought to synthesize the issue of projected trends in paper recycling and timber markets. This is not unexpected, considering that trends in recycling have emerged from the landfill crisis and solid waste management dilemma, rather than from concern about future adequacy of forest resources. However, an awareness of broader materials policy dimensions of recycling was reflected clearly in the report by William Kovacs, former Chief Counsel, U.S. House of Representatives, Subcommittee on Transportation and Commerce. Kovacs described the recent history, challenges, and opportunities of solid waste management and recycling (Kovacs 1988). The title of the Kovacs report itself, "The Coming Era of Conservation and Industrial Utilization of Recyclable Materials," as well as contents of the report, reflected awareness that the Nation stood on the brink of a new era in materials policy, driven by waste management concerns and opportunities in recycling. However, although the Kovacs report became a landmark for discussion of recycling policy options, it is noteworthy that the report did not actually examine any broad economic consequences of such new recycling policies, except by pointing to the likelihood that such policies could be successful in substantially altering waste disposal and material use patterns of the United States. For example, little consideration was given to the question of how increased paper recycling could affect the future of forestry or forest product markets in the United States. It is precisely that analysis of forest product market implications which this study provides, extending an understanding of how new recycling trends will affect society on a broader level.

NAPAP Model

A spatial equilibrium and dynamic process economic model of the North American pulp and paper sector was developed and applied in this study. The model is known as the North American Pulp and Paper (NAPAP) Model (Ince et al. 1993). It was developed to project future technological changes, production, capacity, imports and exports, and related market equilibria for the United States and Canadian pulp and paper sector. For this analysis, the model incorporates basic RPA assumptions of economic growth and population growth discussed previously. It includes five North American production or supply regions (Canada East and West, U.S. North, South, and West), and two North American demand regions (United States and Canada). The model combines regional information on supply and demand, manufacturing processes, and transportation costs to compute future market equilibria year to year, using a price-endogenous linear programming

system. The model determines annual growth in production capacity among different processes and regions as a function of their relative profitability and market conditions. It projects evolution of manufacturing processes, regional markets, and trade, for thirteen principal grades of paper and paperboard, and five grades of wood pulp (including market pulp grades). It projects the regional supply and demand equilibria of pulpwood inputs and recovered paper inputs (recycled wastepaper). The model is also a trade model, providing a capability to simulate trade flows and impacts of trade restrictions and exchange rates between the United States and Canada. The model also accounts for United States and Canadian trade with outside trading regions, including Atlantic, Pacific, Latin American, and other trade regions.

Development of the NAPAP Model was guided by practical observation and economic theory. In the North American pulp and paper sector, and in competitive market sectors generally, technological change and evolution of prices, production, capacity, and trade all occur simultaneously with some interrelationship. Economic theory and models seek to explain how such phenomena are interrelated in an optimizing process, under competitive free market conditions.

Methodology of NAPAP Model

The NAPAP Model is an application of spatial equilibrium modeling methods, based on price-endogenous linear programming, using PELPS III (Zhang et al. 1993). The model represents technological options as economic choices via activity analysis, with production capacity modeled for many different production processes. Recursive programming is used to provide for adjustment in capacity and shifts in supply and demand from year to year.

Nobel laureate Paul Samuelson (1952) described a spatial equilibrium model as one for which:

> ". . . we are given at each of two or more localities a domestic demand and supply curve for a given product (e.g. wheat) in terms of its market price at that locality. We are also given constant transport costs (shipping, insurance, duties, etc.) for carrying one unit of the product between any two of the specified localities."

and from which we wish to know the following:

> "What then will be the final competitive equilibrium of prices in all the markets, of amounts supplied and demanded at each place, and of exports and imports?"

Thus, spatial equilibrium models simulate interregional economies, by finding the balance of supply, demand, and trade which results in a competitive market equilibrium among various regions.

Samuelson (1952) showed that the spatial equilibrium for an economic sector was the solution to a mathematical programming problem. He called the corresponding objective function (to be maximized) the "net social payoff" of the sector. This payoff is the sum of producer and consumer surplus for each region in a sector, minus transportation costs between and within regions.

Maximizing Samuelson's net social payoff has no normative implications beyond that of identifying the regional market equilibria for a sector, described in terms of regional supply and demand curves, and transportation costs between and within these regions. The real justification for its use, other than efficiency in calculating an equilibrium, is therefore that (McCarl and Spreen 1980):

> "... its behavioral implications are consistent with theoretical economic behavior of the sectoral participants. Thus a model with this objective function can be used to simulate producer response to policy."

This ability to simulate producer and consumer responses to changes in the economic environment is important when modeling long-range evolution of technology and market conditions. In the long run, where economic conditions and technological change may occur, the historical data base and conventional econometric approach are not fully adequate. Historical data reflect only historical technological trends and historical conditions, whereas the behavioral model reflects an understanding of the interrelationship between technological change and economic conditions over time (Landau and Rosenberg 1986; Gold 1977; Rosenberg 1982, 1976).

Takayama and Judge (1971, 1970, 1964) introduced an extension of spatial equilibrium methods by representing manufacturing activities in a spatial equilibrium model with activity analysis. Thus, they conceptualized the idea of finding the competitive equilibrium, not only among regions but also among

various manufacturing processes, which were separately described in terms of inputs required per unit of output, unit cost of manufacturing net of inputs, and regional manufacturing capacities.

Given that existing processes in the pulp and paper sector constrain production in the short run, it was logical to model capacity constraints by process, and capacity growth by process over time (as well as by region) using the spatial equilibrium framework. In effect, the NAPAP Model was designed to address issues beyond the original spatial equilibrium problem considered by Samuelson (1952). The NAPAP Model finds the competitive production equilibria among competing regional manufacturing processes in the short run, and forecasts the competitive evolution of capacity by process in the long run.

Changes in capacity are computed by a "q-theory" of capacity expansion, based on the q-theory of capital investment pioneered by Nobel laureate James Tobin (1969). Tobin said,

> "the rate of investment — the speed at which investors wish to increase capital stock — should be related, if to anything, to q, the value of capital relative to its replacement cost."

Following Tobin's q theory, the change in capacity for each production process is determined as an increasing function of the q ratio, the shadow price (marginal profitability) of current capacity to the cost of new capacity. Empirical results with data of the U.S. pulp and paper industry suggest that gross change in capacity of the pulp and paper sector is a function of the current q ratio, the q ratio lagged one period, and the gross change in capacity lagged one period (Zhang and Buongiorno, 1992).

The interaction between demand functions and product supply determines the equilibrium solution for product markets each year. The model also includes an endogenous solution of the regional supply and demand equilibrium for pulpwood and recovered paper, with regional demand determined by raw material requirements of production processes and the simultaneous equilibrium solution for paper and paperboard production. Capacity growth by process is determined by the Tobin q model. As markets and production capacity evolve from year to year, and as new production processes are introduced, the regions and processes that experience the most capacity growth are projected to change. Over time, the model shows how recovered paper and pulpwood markets are expected to respond to shifting demand and changing technology, and, in turn, how technology is expected to evolve in response to market conditions (i.e., supply, demand, and prices for fiber inputs, pulp, paper, and paperboard products). Thus, the NAPAP Model is described more aptly as a "techno-spatial equilibrium model," or one which solves the technology forecasting problem, as well as the classical spatial and production equilibrium problem.

In summary, the NAPAP Model can be thought of as simulating the rational economic behavior of suboptimizing decisionmakers in a generally competitive free market environment (who must rely on temporal economic data to make long-run decisions). Reflecting the reality of decisionmaking in the North American pulp and paper sector, the model simulates the behavior of decisionmakers who face an economic environment each year that has been determined, in part, by their past decisions (e.g. past capacity expansion decisions), and, in part, by prevailing economic conditions which are shaped also by external forces (such as government policies which have increased supplies of recovered paper in recent years). The behavioral realism of spatial equilibrium recursive programming was a major consideration in the decision to use this methodology in simulating pulp and paper sector behavior and responses to change.

Results

Results include projections obtained from the NAPAP Model (pulp and paper trends, recycling trends, and pulpwood markets) and results obtained from the TAMM/ATLAS model (lumber production and sawtimber markets). Results are illustrated in charts, which generally include historical data trends since 1952. The charts compare projections from the 1989 RPA Assessment with the more recently developed projections for the 1993 Update Base scenario and the "High Recycling/Waste Reduction" scenario (noted as "Waste Reduction" in the charts).

Data assumptions and a more detailed presentation of 1993 Update projections by region and product are provided in a background research report (Ince, 1993). As explained in the background research report, the 1993 Update Base scenario on recycling was drawn out of an analysis which was largely unconstrained by government policies (ex-

cept for assumed increases in recovered paper supply in the 1990s, in line with historical trends). By contrast, the alternative "High Recycling/Waste Reduction" scenario was based on the introduction of several significant policy impact assumptions. Those assumptions included the following: (1) An additional 5% per year positive shift in recovered paper supply was introduced in all U.S. regions, for all recovered paper commodities, from the mid-1990s to the end of the projection period; and maximum feasible recovery rates were increased to 80% for ONP, OCC, mixed papers, and certain categories of high grade deinking. These assumptions were intended to simulate extreme possibilities associated with intensification of paper collection policies and recovery programs in the decades ahead. (2) A 20-percent investment tax credit was assumed for investment in processes capable of utilizing recovered paper, simulating a potential government policy incentive for recycling. (3) A 1-percent per year negative shift in U.S. demand growth for all paper and board commodities was assumed from 1995 to the end of the projection period, simulating potential impacts of waste reduction policies and programs.

Paper & Board Consumption

Revisions to paper and board demand estimates for the '93 Update indicate somewhat slower growth in paper and board consumption than projected in the 1989 RPA Assessment (fig. 9). However, in the

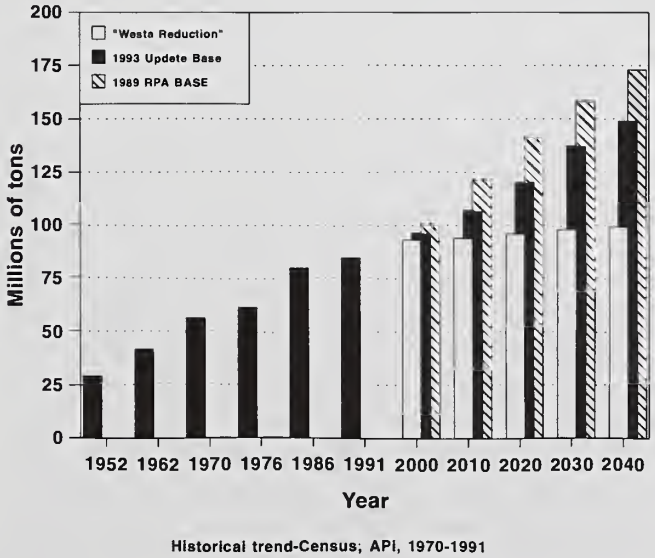


Figure 9.—Paper and board consumption in the United States.

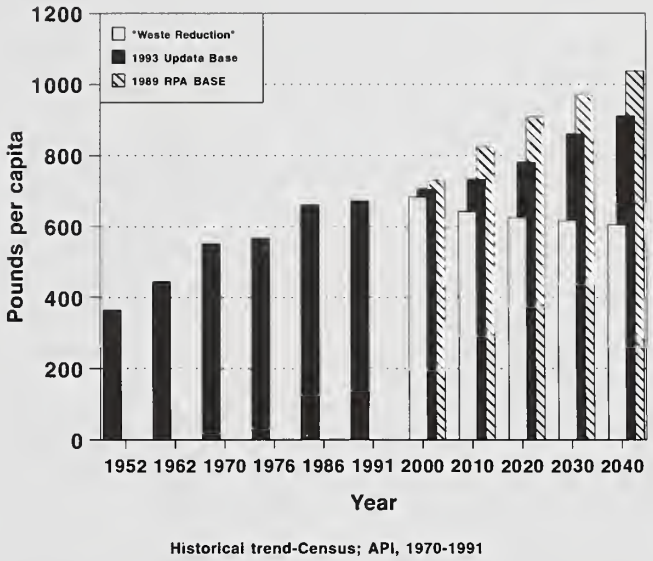


Figure 10.—Per capita paper and board consumption in the United States.

'93 Base scenario, paper and board consumption in the United States still is projected to reach nearly 100 million tons in the year 2000, and nearly 150 million tons by the year 2040. Although projections indicate somewhat slower growth in paper and board consumption than in the 1989 analysis, the base projections still indicate increasing aggregate demand for fiber products (paper and board). Projections are generally in line with historical trends.

The alternative "Waste Reduction" scenario incorporated the assumption that policies and programs aimed at reducing volumes of waste (via more efficient product use, public education, disposal fees, etc.) would result in a compounded -1% per year negative shift in demand growth beyond the year 2000 (relative to the '93 Base scenario). The result was a relatively flat projection of paper and board consumption beyond the year 2000, in the "Waste Reduction" scenario (fig. 9)

Per Capita Paper & Board Consumption

On a per capita basis (fig. 10), projections indicate that U.S. paper and board consumption in the 21st century will rise more slowly than previously projected. Having recently peaked at over 690 pounds per capita in 1988, the '93 Base projections indicate that per capita consumption will increase to about 910 pounds per capita in the year 2040. The "Waste Reduction" scenario results in a gradual decline in per capita paper

and board consumption (fig. 10). Relative to the earlier 1989 RPA Assessment, the current outlook indicates a slower growth in per capita paper and board consumption than in recent decades.

The reduction in projected per capita paper and board consumption is based on several factors, including assumptions about waste reduction (lighter packaging and lower weight paper products) and substitution of alternate technologies for paper and board (e.g. electronic media for print media, and plastics in packaging). In addition, factors which affect fiber supply, such as future constraints on timber supply, will limit paper and board consumption. Projections of U.S. population growth and U.S. GDP growth in the current analysis were nearly identical to projections in the 1989 analysis.

Under the '93 Base scenario, the United States would maintain per capita consumption levels for paper and board which are much higher than per capita consumption levels in other industrialized countries. While per capita consumption in the United States is currently at about 670 pounds, per capita consumption is about 25% lower in Germany and Japan, about 30% lower in Canada, and about 47% lower in the United Kingdom.

Recovered Paper Utilization Rate

The recovered paper utilization rate measures the rate of paper recycling in the United States. It is the ratio of recovered paper consumption in paper and board mills to paper and board production. In the United States, the recovered paper utilization rate actually declined in the 1950s and 1960s. However, beginning in the 1970s, there was a gradual upturn in the utilization rate, reflecting improvements in paper recycling technology (fig. 11). Furthermore, since the mid-1980s, there has been a very substantial increase in paper recycling, which is now reflected by an increase in the recovered paper utilization rate (the recovered paper utilization rate of the United States reached 30% in 1992). The '93 Base projections indicate that the utilization rate will reach approximately 40% by the early part of the next century and 45% by the year 2040 (fig. 11). The "Waste Reduction" scenario assumed that increased recycling would be stimulated further by investment tax credits for recycling facilities, and by continued increases in the intensity of collection programs for recovered paper. Under that scenario, the utilization rate is projected to stabilize at about 60% in the next century (fig. 11).

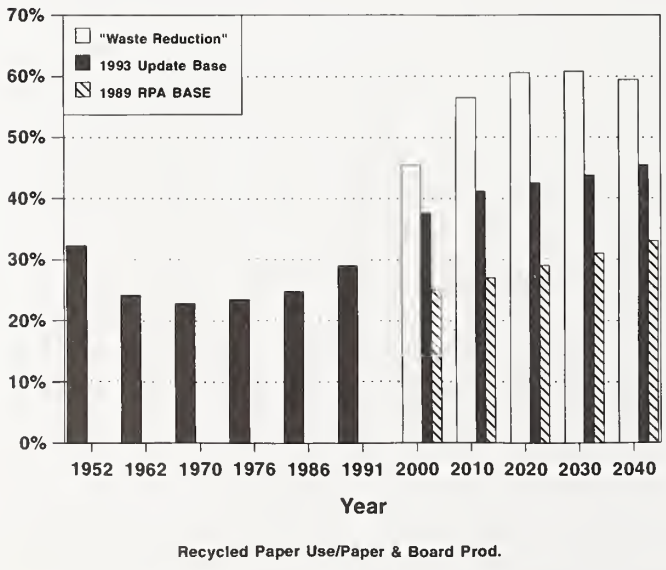


Figure 11.—Recovered paper utilization rate in the United States.

The current view on recycling represents a significant departure from the 1989 RPA Assessment Base scenario. In the 1989 Base scenario, it was assumed that the utilization rate would barely exceed 30% by the year 2040 (a recycling rate which was already reached in the United States by 1992). Other industrialized countries, Germany and Japan for example, have achieved domestic recovered paper utilization rates in the range of 45 to 50%, which are slightly higher than rates projected for the United States in the next century, in the '93 Base scenario. In Japan for example, the utilization rate is now slightly higher than 50%, and a national goal has been set to achieve a 55% utilization rate by the year 2000.

Gross Wastepaper Disposal Burden

The gross wastepaper disposal burden of the United States is defined in this study as the difference between total annual consumption of paper and board, and the total quantity recovered domestically for recycling or export. The gross wastepaper disposal burden would account approximately for all paper and board products which are disposed via landfill, incineration and sewage, net of product volumes which remain in long term storage (in books, etc.). According to that measure, the gross wastepaper disposal burden has increased in recent decades, and was projected to increase very substantially in the 1989 RPA Assessment (fig. 12). However, in the '93 Base scenario, the gross wastepaper disposal

burden is projected to remain relatively constant at current levels (actually declining with increased recycling in the 1990s, and then increasing gradually in the next century). In the "Waste Reduction" scenario, the gross wastepaper disposal burden is projected to decline very substantially in the next century (fig. 12).

Exports of Paper and Board

Although slower growth is projected for domestic consumption of paper and board in the '93 scenarios, exports of paper and board from the United States are projected to increase substantially in the decades ahead (fig. 13). Foreign demand for U.S. paper and board products has been increasing substantially in recent years, and foreign demand is projected to increase steadily into the 21st century. Increased paper recycling extends fiber supply in the United States and enhances the competitive advantage of U.S. producers in overseas markets, enabling the United States to obtain much higher export volumes. Projections in the '93 Base scenario indicate that U.S. paper and board exports will exceed 18 million tons per year by 2040. Exports are projected to be even higher in the "Waste Reduction" scenario.

Imports of Paper and Board

With extended supplies of fiber in the United States, partly resulting from increased recycling, the need for imports of paper and board will be reduced.

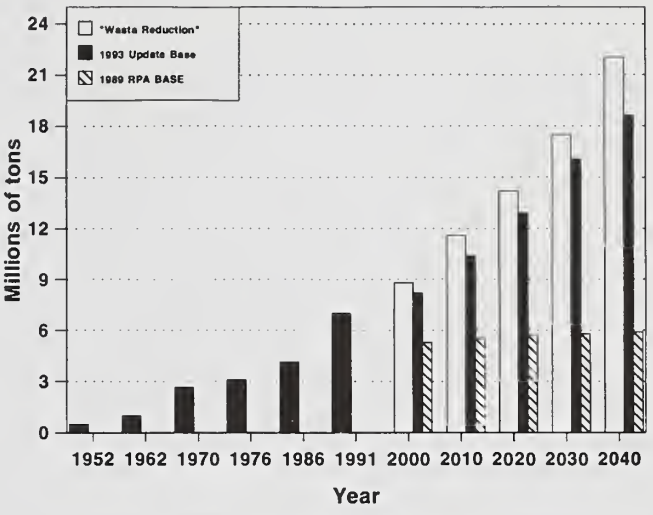


Figure 13.—United States exports of paper and board.

Projections in the '93 Base scenario indicate a gradual long-range decline in paper and board imports to the United States (fig. 14). In the "Waste Reduction" scenario, U.S. imports of paper and board are projected to decline more rapidly in the next century. Increased recycling and increased domestic fiber supply reduces the need for paper and board imports. Current projections generally reflect a view that the United States will become more self-sufficient in fiber supply in the decades ahead, partly becaue of increased recycling.

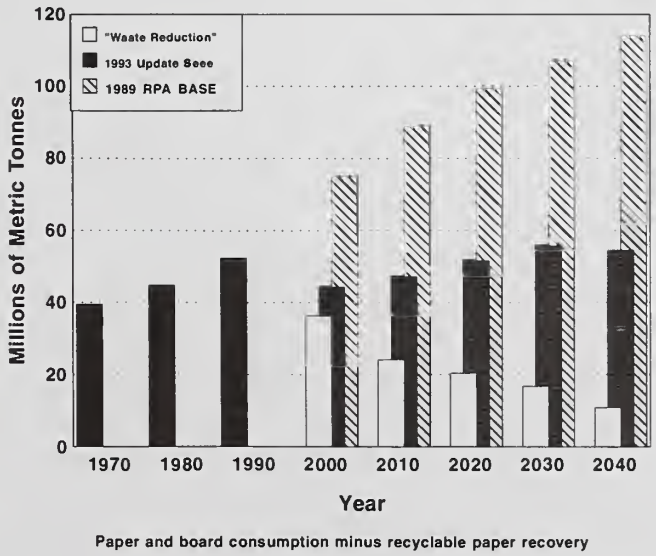


Figure 12.—Gross wastepaper disposal burden of the United States.

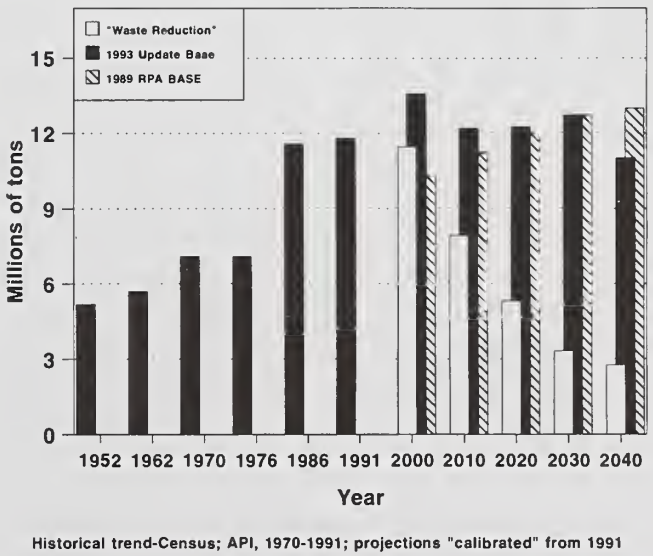


Figure 14.—United States imports of paper and board.

Exports of Woodpulp

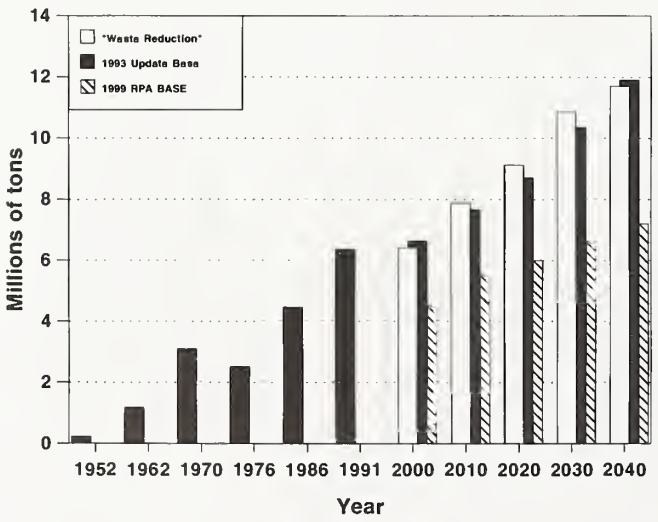
U.S. exports of woodpulp (mostly market pulp) also are projected to increase more substantially in the decades ahead, relative the 1989 Assessment (fig. 15). Growing world market demand, particularly among Pacific Rim countries, is expected to place greater export demands on U.S. woodpulp production. With relatively abundant fiber supplies in the United States, domestic production of woodpulp for export will increase. Current export projections are much higher than export assumptions used in the 1989 RPA Assessment.

Imports of Woodpulp

Although imports of woodpulp to the United States have increased in recent decades, increased substitution of recycled fiber and increased domestic woodpulp production are projected to result in decreased U.S. imports of woodpulp, in the '93 Update scenarios. Current import projections are much lower than assumptions used in the 1989 RPA Assessment (fig. 16).

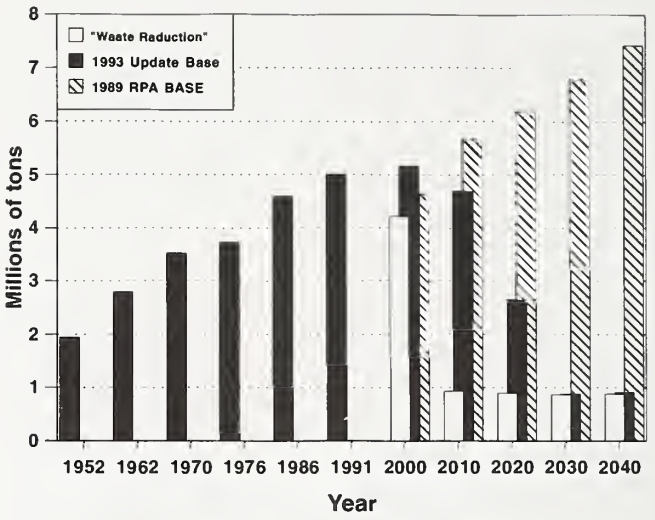
Production of Paper and Board

Projections of U.S. paper and board production were derived after factoring in projected trends in fiber product demand, fiber supply, and projected technological changes in the pulp and paper sector. The '93 Base projections indicate that U.S. paper and board production will grow to nearly 95 million tons in the year 2000, and more than 150 million tons in 2040 (fig. 17). As noted previously, a larger share of production will be for export, while demand for domestic consumption will grow more slowly. In the "Waste Reduction" scenario, production is projected to increase; but, production reaches only about 120 million tons in 2040. Although projections of production for the year 2000 are similar to those of the earlier 1989 RPA Assessment, projections now indicate a somewhat slower growth in production into the 21st



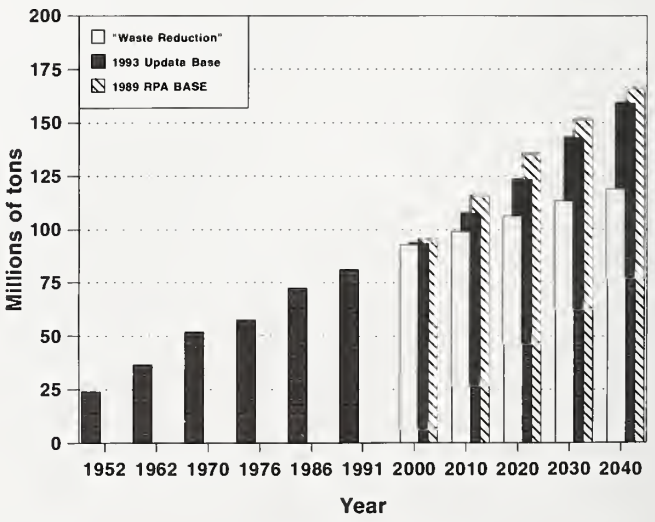
Historical trend-Census; API, 1970-1991.

Figure 15.—United States exports of woodpulp.



Historical trend-Census; API, 1970-1991; projections "calibrated" from 1991.

Figure 16.—United States imports of woodpulp.



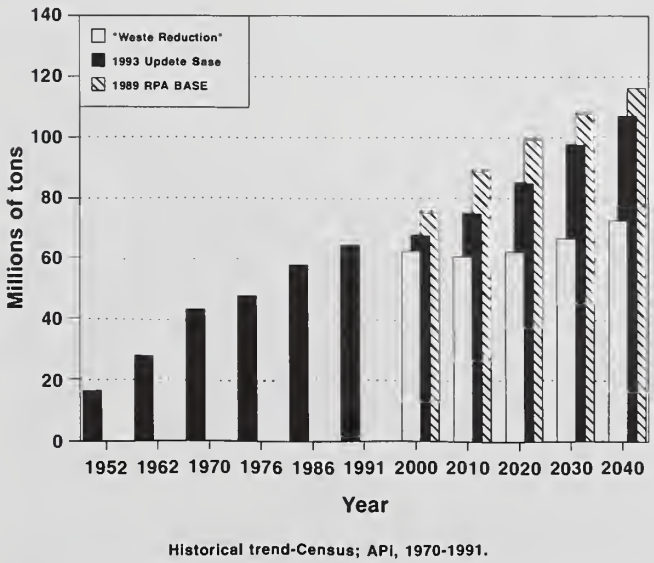
Historical trend-Census; API, 1970-1991

Figure 17.—Production of paper and board in the United States.

century. However, current projections remain roughly in line with historical trends; and projections still indicate substantial growth in U.S. paper and board production in the decades ahead. Increased fiber supply resulting from increased recycling helps facilitate the projected growth in paper and board production.

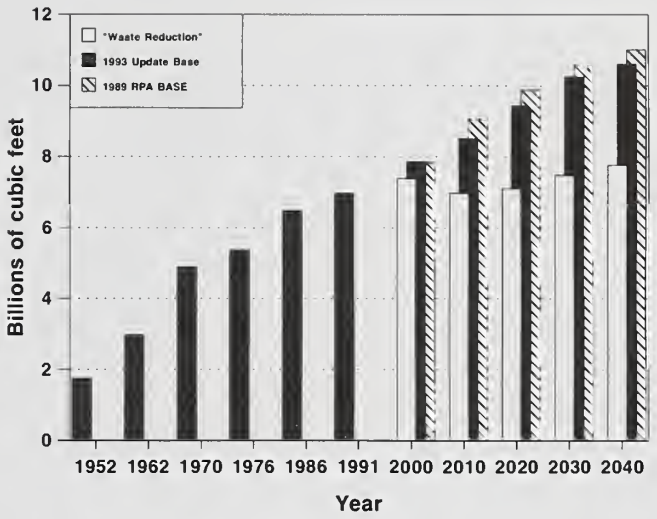
Production of Woodpulp

Given projected increases in paper recycling, and more modest projected growth in paper and board production, production of virgin woodpulp in the United States currently is projected to grow at a slower rate than projected in the 1989 RPA Assessment. In the '93 Base scenario, woodpulp production is projected to grow very slowly in the 1990s, as recycled fiber is utilized at much higher rates (fig. 18). In the case of market pulp, a growing share of production is projected to be obtained by pulp made from recycled fiber (which is not included in the woodpulp projections). Beyond the year 2010, woodpulp production grows more closely in tandem with growth in paper and board production, as recovered paper utilization begins to stabilize. Growth in woodpulp exports contributes to projected growth in woodpulp production. In the "Waste Reduction" scenario, woodpulp production is projected to remain relatively flat into the next century (fig. 18).



Historical trend-Census; API, 1970-1991.

Figure 18.—Production of woodpulp in the United States.



Historical trend-Census; APA, 1991

Figure 19.—Total pulpwood supply of the United States (including mill residues).

Total Pulpwood Supply

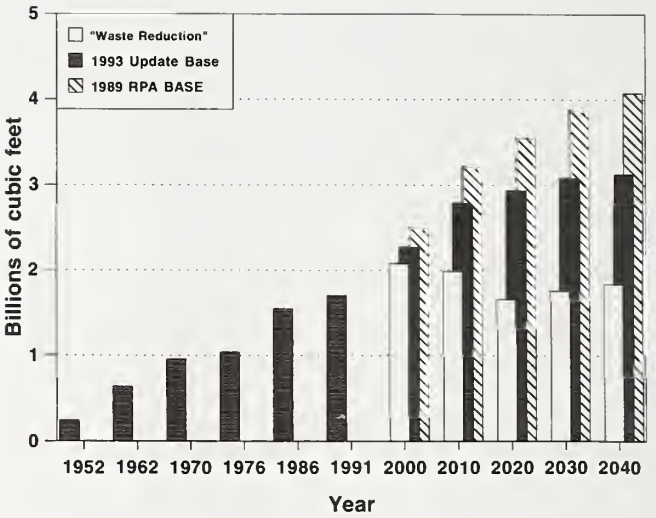
Total pulpwood supply of the United States, including domestic consumption and exports, will continue to increase according to the '93 Base projections, but total pulpwood supply will be somewhat lower than projected in the 1989 RPA Assessment (fig. 19). The lower pulpwood supply projection occurs as the result of two primary factors, slower growth in woodpulp production and tighter constraints on pulpwood supply, particularly hardwood pulpwood supply in the South. In the "Waste Reduction" scenario, total pulpwood supply remains relatively flat into the next century (fig. 19).

Softwood Pulpwood Supply

The supply or harvest of softwood roundwood pulpwood in the United States now is projected to grow at a significantly more modest rate than projected in the earlier 1989 RPA Assessment (fig. 20). Increased supplies of secondary (recycled) fiber and increased supplies of mill residues, coupled with slower growth in woodpulp production, will afford only relatively modest growth in harvest of softwood pulpwood in the United States. In the "Waste Reduction" scenario, softwood pulpwood harvest is projected to decline gradually, and then increase beyond the year 2010 (fig. 20).

Hardwood Pulpwood Supply

The supply or harvest of hardwood roundwood pulpwood in the United States is projected to grow at a much more modest rate than projected in the earlier 1989 RPA Assessment (fig. 21). Although technological changes in the pulp and paper sector can accommodate increased use of hardwoods, hardwood roundwood pulpwood supplies are assumed to become more constrained in the South beyond the year 2000, primarily because of projected declines in hardwood timber inventories, in the South. In the "Waste Reduction" scenario, hardwood pulpwood harvest is projected to decline in the next century (fig. 21).



Historical trend-Census; APA, 1991

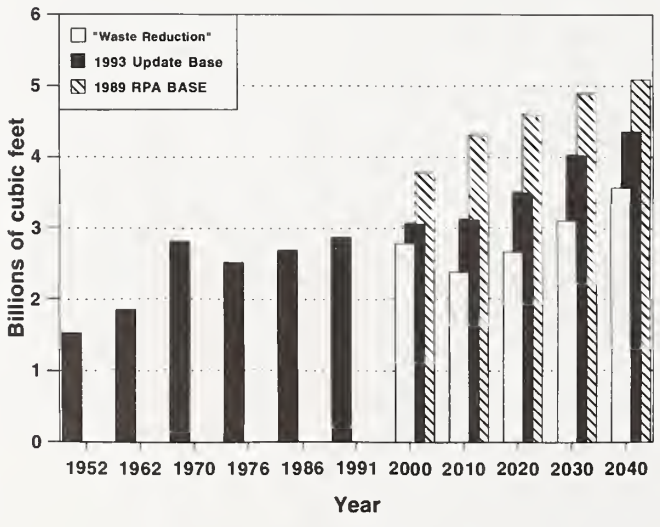
Figure 21.—Hardwood roundwood pulpwood supply of the United States.

Pulpwood Residues

Supplies of pulpwood, in the form of mill residues (sawmill and plywood mill residues), are projected to increase rather modestly in the decades ahead (fig. 22). Projected supply levels are somewhat higher than in the 1989 RPA Assessment, partly because of higher projections of lumber production and because of technical adjustment of mill residue conversion factors (residue output per unit of lumber and plywood produced). Pulpwood residue supply projections are now in line with historical trends. The '93 projections indicate that pulpwood residue supplies will level out and gradually decline in the next century, partly because of efficiency improvements in lumber and wood panel production, which will reduce residue outputs.

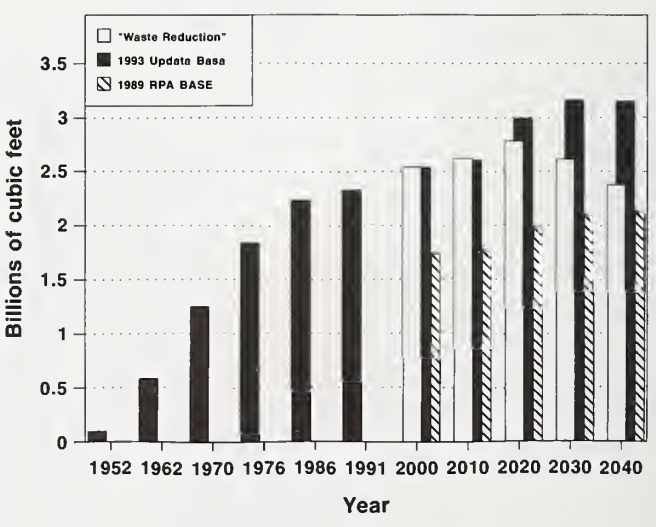
Southern Softwood Pulpwood Price Index

Looking at the projected index of delivered softwood roundwood pulpwood prices in the U.S. South (a primary indicator of U.S. pulpwood prices), substantially lower softwood pulpwood prices are projected in the '93 Update than in the 1989 RPA Assess-



Historical trend-Census; APA, 1991

Figure 20.—Softwood roundwood pulpwood supply of the United States.



Historical trend-Census; APA, 1991

Figure 22.—Supply of pulpwood residues (mill residues) in the United States.

ment Base scenario. The '93 Base projections indicate a decline in the softwood pulpwood price index for the next several decades, associated with increased recycling (fig. 23). Toward the end of the projection period, the softwood pulpwood price index climbs gradually, as paper recycling rates stabilize and consumption of virgin fiber increases more rapidly. Throughout the projection period, the softwood pulpwood price index is projected to remain below its 1986 level. In the "Waste Reduction" scenario, softwood pulpwood prices are projected to decline even more substantially (fig. 23).

Southern Hardwood Pulpwood Price Index

In contrast to the softwood pulpwood price index, the delivered hardwood pulpwood price index for the U.S. South is projected to increase in the long run, primarily because of reduced price elasticities of supply for hardwood pulpwood in the South. With increased recycling, the hardwood pulpwood price index is projected to decline by the year 2000; but then it is projected to increase through the remainder of the projection period (fig. 24). The projections reflect a view that hardwood pulpwood supplies in the South will be constrained significantly beyond the year 2010, as hardwood timber inventories are projected to decline. Nevertheless, with increased recycling, the hardwood pulpwood price index is projected to be substantially lower than projected in the 1989 Assessment.

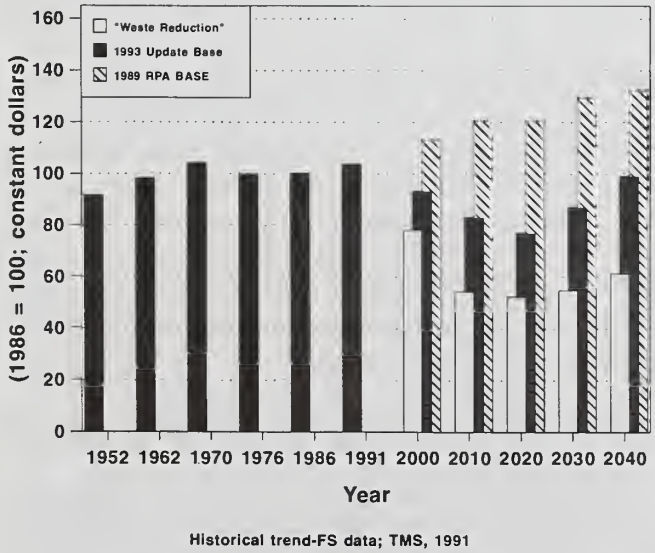


Figure 23.—Softwood pulpwood price index in the U. S. South.

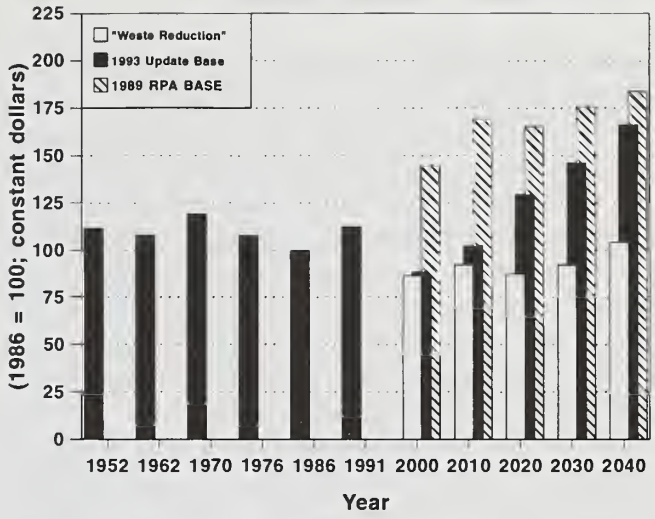


Figure 24.—Hardwood pulpwood price index in the U. S. South.

Softwood Lumber Production

While increases in paper recycling rates and paper and board production are projected in the decades ahead, projections from the TAMM model indicate increases in demand for "solid-wood" products, such as lumber and structural panels (plywood and OSB). Softwood lumber production in the United States is projected to increase at a pace which is generally in line with the earlier 1989 RPA Assessment projections (fig. 25).

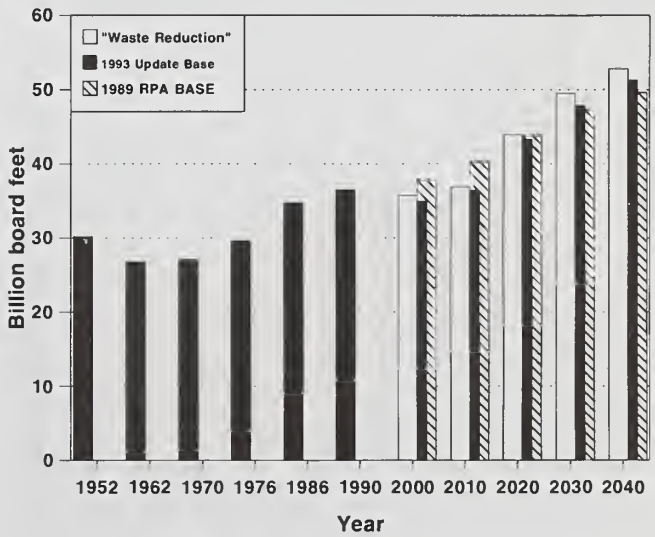


Figure 25.—Softwood lumber production in the United States.

National Forest Timber Harvest

The '93 RPA Update assumes substantially lower National Forest timber harvest levels than in the earlier 1989 RPA Assessment (fig. 26). In fact, timber harvest levels on the National Forests already have declined in recent years, in the process of resolving many issues related to management of forest resources on the National Forests, protection of endangered species, etc. Thus, current projections of much lower timber harvest on the National Forests reflect realities of the substantially reduced National Forest timber harvest levels of recent years.

Most of the reduction in timber harvest levels, on the National Forests, is in the form of reduced softwood sawtimber harvest. In terms of fiber supply for pulp and paper products, most of the impact will be felt in the Pacific Northwest region, where mills traditionally have relied for pulpwood on softwood mill residues from lumber and plywood mills. Most of the future growth in pulp, paper, and board production capacity is projected to occur in the eastern part of the United States, and primarily in the South.

U.S. Private Forest Timber Harvest

Although National Forest timber harvest levels are assumed to be substantially lower in the decades ahead, a somewhat slower growth in timber harvest also is projected on private forest lands (forest industry and other private forest lands), in the United States (fig. 27). The projected timber harvest on private forest lands is generally lower than that which

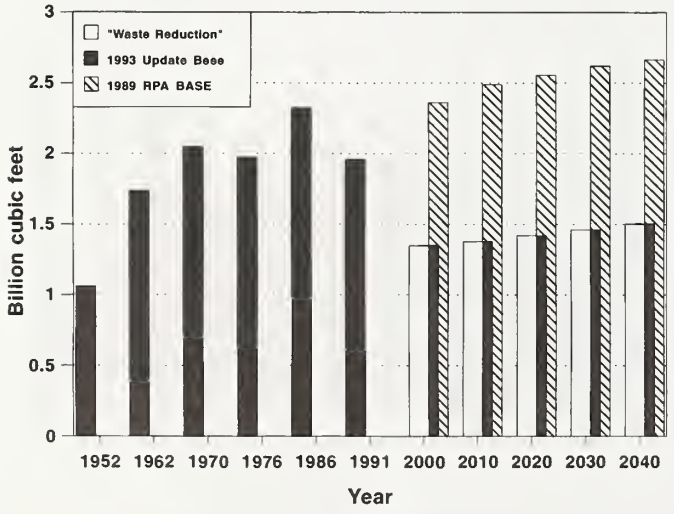


Figure 26.—U. S. national forest timber harvest.

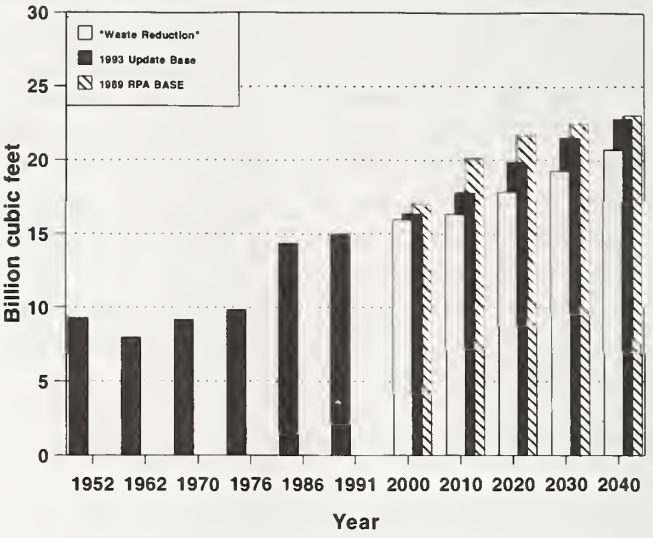


Figure 27.—U. S. forest industry and other private timber harvest.

was projected in the 1989 RPA Assessment, largely because of projected increases in paper recycling rates.

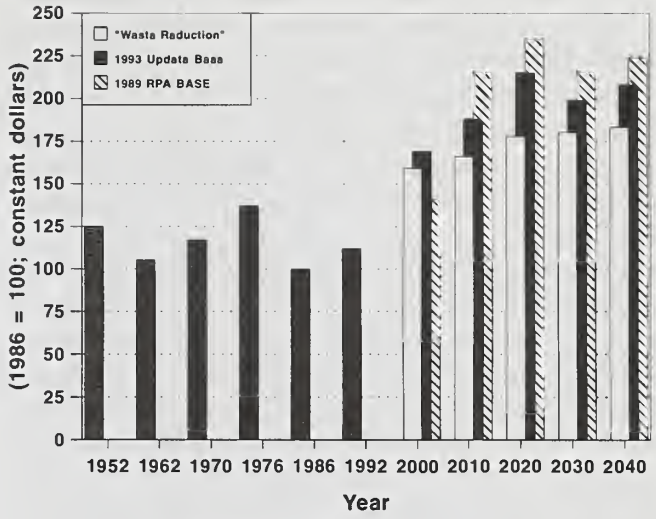
U.S. Timber Harvest (All Owners)

Overall, U.S. timber harvest is now projected in the '93 Update to grow at a slower rate than projected in the earlier 1989 RPA Assessment (fig. 28). Several key factors contribute to the slower projected growth in timber harvest. The most significant factors are the revised outlook on paper and board consumption, woodpulp production, and paper recycling. Overall, timber harvest will be reduced by several billion cubic feet per year, in the early part of the next century, relative to the 1989 RPA projections; but, not all of that reduction may be attributed to increased recycling or changes in the pulp and paper outlook. Also important are other adjustments which have been made in the timber supply outlook. The National Forest timber harvest outlook was reduced relative to earlier projections; and future timber supplies are now assumed to be somewhat less elastic than in the 1989 Assessment.

Southern Softwood Sawtimber Stumpage Index

Although projections in the 1993 Update indicate that overall timber harvest levels will grow more slowly than projected in the 1989 Assessment, the near-term prognosis for softwood sawtimber sup-

plies remains constrained, and sawtimber prices are projected to increase (fig. 29). National Forest timber harvest levels are projected to be much lower; and demand for lumber, plywood and panel products in housing are projected to be somewhat higher. In contrast to pulpwood price projections, softwood sawtimber prices in the '93 Base scenario are projected to increase very substantially in the next couple of decades, and then gradually level off because of the combined effects of increased recycling and the maturation of pine plantations in the South. Beyond the year 2010, however, sawtimber price projections in the '93 Base scenario are somewhat lower than in the 1989 Assessment Base (fig. 29). In the "Waste Reduction" scenario, sawtimber prices are projected to remain relatively stable in the next century, after increasing in the next decade (fig. 29).



Historical trend-FS data; TMS, 1992

Figure 29.—Softwood sawtimber stumpage index in the U. S. South.

Conclusions

Rapid increases in recycling and exports of recovered paper are projected to alter the balance between fiber supply and demand in the United States, eventually leading to stabilization of paper recycling rates at much higher levels in the next century. The '93 Base scenario indicates that rapid increases will occur in U.S. paper recycling rates in the 1990s, eliminating the current wastepaper glut within the decade, followed by more gradual increases in subsequent decades. In 1992, the recyclable paper utilization rate was approximately 30% in the United States. In the Base scenario, without significant government policy intervention, the utilization rate in the United States would eventually stabilize at about 45%, toward the middle of the next century. In the "Waste Reduction" scenario, with significant policy intervention to promote paper recycling and waste reduction, the utilization rate might stabilize at about 60%, in the next century.

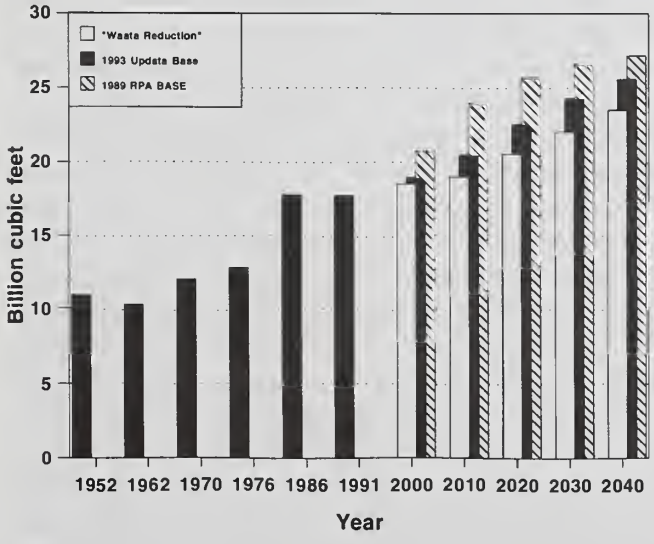


Figure 28.—U.S. timber harvest (all owners).

Fiber supply will sustain increases in paper and board production in the United States, with increased use of recycled fiber. Exports of paper and board products are projected to grow substantially, while imports are projected to generally decline (particularly imports from Canada) as the United States becomes more self-sustaining in fiber needs, with increased recycling. However, government policies aimed at waste reduction could result in slower growth in domestic demand and production of paper and board products. Annual production of paper and board in the United States was about 80 million tons in 1990. In the '93 Base scenario, annual U.S. paper and board production is projected to reach more than 150 million tons by the year 2040. However, in the "Waste Reduction" scenario, annual U.S. paper and board production is projected to reach only about 120 million tons by the year 2040, with growth in paper and board demand constrained by waste reduction policies.

In the '93 Base scenario, more rapid increases in recycling and slower growth in per capita paper and board consumption contribute to somewhat slower projected growth in pulpwood harvest than in the 1989 Assessment. However, pulpwood consumption still is projected to increase, unless future growth in paper and board demand is reduced substantially by waste reduction policies. Increased paper recycling will help to extend forest resources of the United States. Pulpwood harvest levels and overall timber harvest levels of the United States are projected to increase in the '93 Base scenario; but, harvest levels are projected to be lower than projected in the 1989 Assessment. Technological changes and market conditions are projected to favor more use of hardwood pulpwood; but, use of softwood pulpwood also would increase toward the end of the projection period. Delivered pulpwood prices are projected to remain fairly stable in the future, and somewhat lower than projected in the 1989 Assessment. Hardwood pulpwood prices will increase in the next century, partly because of projected constraints on hardwood timber supplies. In the "Waste Reduction" scenario, pulpwood harvest is projected to remain relatively flat into the next century, with substantially lower projected pulpwood prices.

Implications

Implications are discussed in the context of the following questions related to timber resources and recycling.

1. Will increased paper recycling extend timber resources?

Yes, projections indicate that increased paper recycling will extend timber resources of the United States. Compared with projections from the 1989 RPA Assessment, projections in the '93 Base scenario indicate slower growth in pulpwood harvest and slower growth in overall timber harvest of the United States, largely because of projections of higher paper recycling rates. Compared with results of the 1989 RPA Assessment, the '93 Base projections indicate the likelihood of relatively stable pulpwood prices in the future with increased recycling. In the "Waste Reduction" scenario, substantial decreases in pulpwood prices are projected. Softwood sawtimber stumpage prices are projected to increase in the 1990s; but, increased recycling helps to stabilize sawtimber stumpage prices in the next century.

2. Can increased paper recycling eliminate all U.S. timber supply problems?

No, although increased recycling will make the situation better than it would otherwise have been. The United States still faces near-term supply problems for softwood sawtimber in the 1990s. The 1989 RPA Assessment assumed much higher future harvest levels on the National Forests. Most of the current reduction in National Forest timber harvest will come at the expense of projected softwood sawtimber harvest in the West. Other adjustments in data assumptions since the 1989 RPA included higher volumes of softwood lumber and plywood consumption in the United States per unit of new housing, lower Canadian lumber production, lower private industrial sawtimber harvests in the U.S. West, increased imports of softwood lumber, and reduced softwood log exports from the Pacific Northwest. Consequently, although projections of U.S. paper recycling rates are now higher and timber harvest levels lower than earlier projections, increased paper recycling will not be sufficient to make up for projected reductions in National Forest timber harvest levels in the 1990s. A substantial increase in softwood sawtimber stumpage prices is projected in the 1990s, in both the '93 Base and "Waste Reduction" scenarios.

3. What aspects of the timber supply and demand outlook remain problematic?

Supplies of softwood sawtimber will remain constrained and prices will increase, limiting growth and competitiveness for softwood lumber and plywood. The commercially available softwood sawtimber resource will continue to shift progressively toward younger age classes, reducing availability of larger diameter softwood sawtimber. Technology of the lumber and plywood sector is likely to continue to shift from traditional "solid-wood" products, such as softwood dimension lumber and softwood plywood, toward alternative composite wood products, such as oriented strand board (OSB), which can be made from pulpwood-type raw material. Production capacity also will continue to shift from the West to the South and North. The pulpwood supply and demand situation is projected to be quite stable, with fiber supply adequate to sustain growth trends of the pulp and paper sector. Increased recycled fiber sup-

ply will augment fiber resource needs of the pulp and paper sector. Some reductions will occur in hardwood timber inventories, particularly in the South.

4. What are the implications of projected market trends for forest management?

Projections indicate that there will be a growing differential between sawtimber and pulpwood prices in the future, with sawtimber prices increasing while pulpwood prices remain relatively stable. This would appear to enhance future timberland investment in management practices aimed at sawtimber production, although pulpwood production often is a coproduct of sawtimber production. In addition, technological changes in products which can substitute pulpwood-type raw material for sawtimber will be favored by market conditions, potentially causing more demand to shift from sawtimber to pulpwood in the future. Reductions in National Forest timber harvests, particularly in the West, will limit supplies of pulpwood residues and stimulate greater investment in pulpwood harvesting and pulpwood plantations in the West. The projected escalation in sawtimber prices would substantially increase timber sale revenues per unit of timber sold on National Forests, as well as on private lands. Thus, although the quantity of timber sold on the National Forests may decline in the decades ahead, timber sale revenues may not necessarily decline in direct proportion to declining harvest volume, and sale revenues may actually increase per unit of land area under timber management. There could be less of a need for government programs designed to stimulate private timberland investment, if higher sawtimber prices lead to a substantial private sector investment response. However, such an investment response by the private sector is not certain (studies have shown that private timberland investment behavior responds to many factors besides the price of timber). In any case, other public policy concerns, such as the sequestration of atmospheric carbon in growing trees, may result in the need for continued public investment in timber management.

5. Can increased paper recycling reduce the waste disposal burden of the United States?

Yes, the historical trend of increasing wastepaper disposal volumes will be offset by increased paper recycling and increased export of recovered paper. In the '93 Base scenario, the gross wastepaper disposal burden of the United States (requiring disposal by landfilling, incineration, or other means) is projected to decline somewhat by the year 2000, and to remain relatively stable into the next century, at levels close to current levels. In the "Waste Reduction" scenario, the gross wastepaper disposal burden is projected to decline substantially within the next several decades.

6. Will increased recycling contribute to a better balance of trade for the United States?

Yes, increased paper recycling will extend U.S. fiber resources and contribute to enhanced competitiveness for the U.S. pulp and paper sector (and will also extend timber resources for the lumber and plywood sectors). Increased export and decreased import of pulp, paper, and paperboard products will significantly improve the U.S. balance of trade.

7. What implications are there for forestry research or forest products research, associated with projected trends in recycling and timber markets?

Although many elements of the current analysis are substantially different than the analysis presented in the 1989 RPA Assessment (e.g. much higher recycling rates and much lower future National Forest timber harvest levels), many earlier conclusions remain valid. Forestry research should continue to focus on sustaining forest productivity and economic development while sustaining the integrity of forest ecosystems. Management of forest ecosystems, new forms of timber management, and new timber harvesting techniques will be important areas of research. Forest products research will need to maintain a focus on extending timber resources, particularly in extending sawtimber supplies and finding alternate technologies for producing solid-wood products from non-sawtimber resources (including pulpwood, recycled materials, etc.). Much research in the pulp and paper sector will need to focus on producing quality products from recycled fiber.

In addition to forestry and forest products research, experience in this study suggests additional topics for resource economics research. Long-term expectations for demand and trade in pulp and paper products is an emerging topic, given ongoing growth in export demand and recent leveling off of per capita domestic consumption. Additionally, long-range assessment of broader environmental consequences of changing technology is a growing area of interest.

This study focused mainly on paper recycling; but, other environmental concerns also are important in the pulp and paper sector, such as concerns about process-specific water effluent and air emissions. Methods developed for technology forecasting in this study (i.e., NAPAP Model) can be used also to assess other long-range environmental benefits or costs of technological changes in the pulp and paper sector. In addition, the modeling methods of the NAPAP Model (e.g., PELPS III) now can be used to develop a similar model of the solid-wood products sector (an activity which is already being undertaken at FPL in cooperation with Forestry Canada). It is planned that, eventually, the PELPS-based solid-wood products model will be merged with the NAPAP Model to examine issues related to technological changes and resource interactions in both sectors, simultaneously. While increased recycling may limit growth in demand for pulpwood, higher sawtimber prices are likely to stimulate increased demand for the use of pulpwood-type raw material in new composite or engineered wood products. When the solid-wood product model is merged with the NAPAP Model, research can be directed at the issue of the future interaction between pulpwood markets and markets for similar wood raw materials used in new composite or engineered wood products. The modeling methods developed in this study can be improved further and applied in analyses of these and related issues.

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Abstract

Ince, Peter J. 1994. Recycling and long-range timber outlook. General Technical Report RM-242. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 23 p.

This report provides analysis of long-range trends in paper recycling and impacts on the timber outlook for the 1993 RPA Assessment Update. Paper recycling is projected to increase substantially in the next decade, followed by more gradual increases in subsequent decades. Increased recycling will extend timber resources and fiber supply.

Keywords: Timber outlook, supply and demand, paper recycling, RPA, assessment